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ENVIRONMENTAL IMPACT WITH THE GREENHOUSE GASES AND AIR POLLUTANT PREDICTION BY DRILLING AND BLASTING WORKS

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ABSTRACT – During drilling and blasting in rocks, there is an emission of certain gases, such as CO_2, CO, NOx, etc. With the development of technology and the application of modern software available on the market today, it is possible to control the level of gas emissions, analyse their impact on the environment, and predict gas emissions produced by drilling and blasting. This paper will present the possibility of analysing and controlling gas emissions using the O-PitEco software, a product of the O-PitBlast company. Importing the parameters of drilling and blasting, as well as using the database of the software itself (technical characteristics of explosives, initiation systems, etc.), it is possible to control and analyse the results, as well as predict the environmental impact. The software offers overview data in the form of various diagrams, statistically processed data and the possibility of printing all the results in the form of an overview report. With the development of modern technologies, monitoring systems and the possibility of predicting certain segments in the mining field have significantly improved. In that case, there is the possibility of correcting certain parameters during the design of drilling and blasting works, to obtain the best possible effect of rock fragmentation with minimal emissions of harmful gases, which contributes to the reduced environmental impact.

Keywords: Greenhouse Gas (GHG), Modern Technologies, O-PitEco, Environmental Impact, Air Pollutants.

INTRODUCTION

In drilling operations, the main goal of equipment selection is to achieve maximum production output with minimum costs and environmental impact. During drilling, the main environmental problems are related to air pollutants (particulate matter PM_{10}, total suspended particulate matter TSP, carbon dioxide CO_2, carbon monoxide CO, nitrogen oxides NO_x, sulfur oxides SO_x and volatile organic compounds VOCs) [1].

During blasting, a considerable amount of gases is released, if the decomposition is

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carried out during a normal explosion, then the produced gases are: nitrogen, carbon dioxide, water vapour and possibly smaller amounts of oxygen. In addition to the chemical composition of explosives, which influences the composition of gas products after blasting, also depends on blasting conditions, explosive cartridge plastic film, the physical characteristics of explosives, rock characteristics, stemming, etc. Harmful gases can also appear in the explosive decomposition products, such as carbon dioxide CO_2, carbon monoxide CO, nitrogen oxides; nitrogen monoxide NO and nitrogen dioxide N_2O, then sulfur gases; hydrogen sulphide H_2S and sulfur dioxide SO_2 [2].

Drilling and blasting operations must be well optimized to prevent negative impacts, where one of the negative impacts is the emission of harmful gases during drilling and blasting, i.e. environmental impact. Modern software for optimizing drilling and blasting parameters can be used for optimization to improve the effects of blasting and reduce the negative impact that occurs after blasting. Software that can be used for analysis, control and prediction of emissions of harmful gases during drilling and blasting is O-PitEco, a product of the company O-Pitblast [3]. O-PitEco is software designed to analyze, predict, and control emissions of GHG and air pollutants in mining operations. This software estimates the environmental impact of drill and blast activities and provides tools to minimise it [4].

GREENHOUSE GASES (GHG) AND AIR POLLUTANT

Greenhouse gases (GHGs) are gases in the atmosphere that raise the Earth's surface temperature, and what distinguishes them from other gases is that they absorb wavelengths of radiation emitted by the planet, resulting in the greenhouse effect [5]. GHG include seven gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) [6]. Figure 1 shows the global emission of GHG gases by different economic sectors.

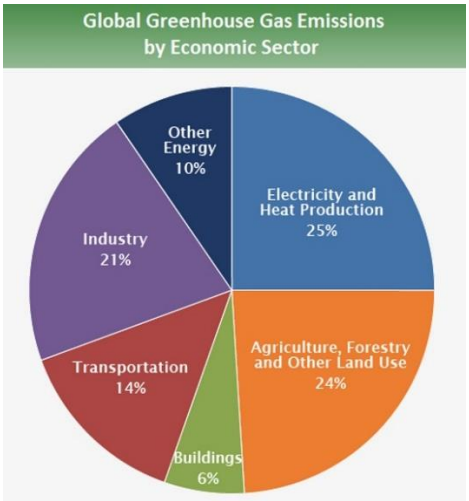

Figure 1 Global greenhouse gas emissions by economic sector [7]

Air pollutants are harmful to human health the environment and biodiversity. They can cause a range of adverse health outcomes for humans, including the risk of respiratory infections, heart disease and lung cancer. Air pollution also has an impact on biodiversity and the condition of the environment [8]. These pollutants are generally collected in two subgroups gaseous (SO_2, NO_x, HC, CO, CO_2) and dust (smoke, metallic smoke, fly ash, mist, aerosols) [9]. Some emissions of the main air pollutants are shown in Figure 2.

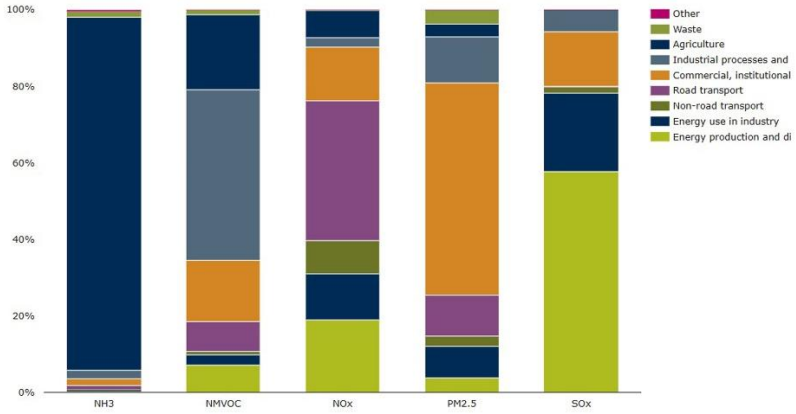

Figure 2 Emissions of the main air pollutants by sector group (NH_3: ammonia; NMVOCs: non-methane volatile organic compounds, such as benzene, ethanol, etc. NO_x: nitrogen oxides is a generic term for the mono-nitrogen oxides NO and NO_2; $PM_{2.5}$: fine particular matter consists of fine particles with a diameter of 2.5 micrometres or less; SO_x: sulphur oxides is a term that refers to many types of sulphur- and oxygen-containing components (SO, SO_2, SO_3, S_7O_2, S_6O_2, S_2O_7, etc.)) [10]

INPUT DATA FOR ANALYSIS

Rock properties

For the analysis, control and prediction of gas emissions during drilling and blasting for this paper, we use data from the quarry, where we have certain characteristics of the rock mass and projected drilling and blasting parameters. The characteristics of the working environment are shown in the following Table 1, where we have given the physical and mechanical properties of limestone.

Table 1 Rock mass properties

Rock mass	Limestone
Density (g/cm^3)	2.66
Compressive strength (MPa)	79
Velocity of P-wave (m/s)	3 500

Drilling and blasting parameters

Drilling and blasting parameters were done using O-Pitblast software, which is used to optimise drilling and blasting work. The design of the parameters was done in the software to obtain the best possible results in terms of fragmentation, with a minimum negative impact as possible during blasting. We exported the parameters designed in this way and presented the data in Table 2, to use them in the O-PitEco software and perform analysis and prediction of harmful gas emissions.

Table 2 Designed drilling and blasting parameters

Parameters	Value
Number of blastholes	114
Volume of production	22 572 m^3
Diameter of borehole	89 mm
Burden	3.3 m
Spacing	4 m
Subdrilling	0.5 m
Stemming	3 m
Bench height	15 m

Parameters in O-PitEco software

The development of specialised software in the area of drilling and blasting made it possible to optimize parameters while achieving the best possible blasting results and reducing the negative environmental impact. Digitisation is one of the biggest vectors of change in the industrial sector, particularly in the mining sector. Digital optimisation tools can dramatically increase the productivity and sustainability of drilling and blasting operations [10].

Imported parameters for analysis and evaluation are shown in the following Figure 3, where the software for the entered parameters has an additional database with a description of the amount of gas emissions during: production, transportation, charging and detonation.

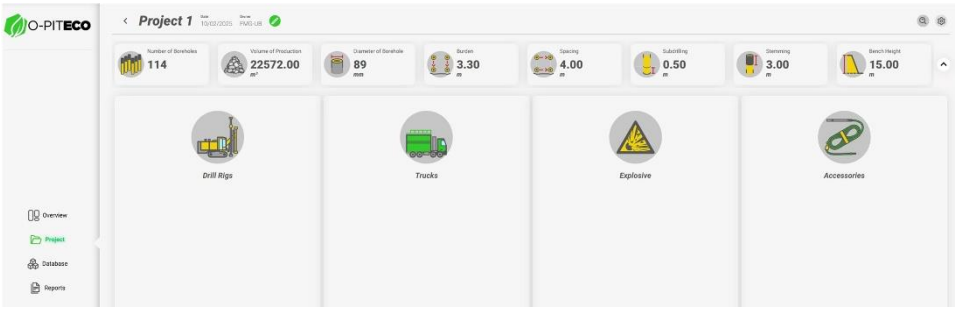

Figure 3 Drilling and blasting parameters imported in O-PitEco

RESULTS AND DISCUSSION

The software analysis used the drilling and blasting parameters shown in Table 1, while the database from the software itself was used for emission assessment or prediction. The database already has various characteristics, such as the technical characteristics of the explosives, where in this case emulsion cartridge explosives were used in combination with ANFO explosives with non-electric initiation systems. In this case of analysis, the emission of gases from the explosives and the assessment of which segment has the greatest impact on the environment will be shown. The following Figure 4 graphically shows the results based on the entered drilling and blasting parameters for the environmental impact (example for CO_2 emissions in kg).

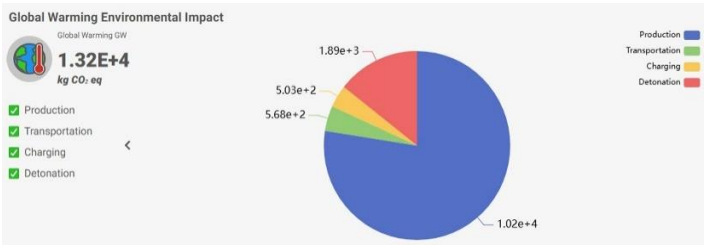

Figure 4 Result of emission from O-PitEco for CO_2

After analyzing the entered drilling and blasting parameters, we have a diagram that shows the emission of harmful gases during blasting and the emissions for all segments as production, detonation, charging, and transportation of explosives. Where the amount of CO_2 total emissions is 13,200 kg, or by segments 1,890 kg during detonation, 503 kg for charging 568 kg for transportation, and 10,200 kg for production. Based on the analysis and the presented diagram for the emission of CO_2, we can see that of the mentioned processes, the most emissions occur during the production of explosives, followed by detonation and much less emissions during transportation and charging. For detonation calculated emission software for CO is 20.5 kg and for nitrogen oxides (NO_x) is 0.000182 kg, where this amount can be reduced by reducing drilling and blasting parameters.

CONCLUSION

Based on the application of the O-PitEco software, which is presented in this paper, it is possible to analyze and assess the impact, that is, the amount of gases during drilling and blasting. The application of such software can significantly contribute to the analysis and assessment of the impact on the environment in mining, but also to the prediction of emissions during the optimization of various drilling and blasting parameters. Changing various parameters in the optimization software, as well as by applying different types of explosives can be corrected in terms of emissions of harmful gases before blasting itself.

In addition to the presented emission assessment for CO_2, CO and NO_x, for explosives and how much each segment affects the amount of gas emissions, other analyses are

possible. Impact assessment during drilling operations is one of the processes that can also be analyzed, as well as the impact during the application of mechanized vehicles for charging blastholes.

In terms of environmental protection, this kind of software can be very important, because recently the topic of emission of harmful gases and particles, which are dangerous to human health, in this case, gases as products of blasting or emission of GHG gases that affect global warming, is very current. The need for these and similar software tools will probably continue to grow and their development will certainly progress.

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